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INFLUENCE OF NEONATE'S BODY POSITION WITH AND WITHOUT A PLASTIC BLANKET ON BODY HEAT LOSS ASSESSED FROM A THERMAL MANNEQUIN

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INTRODUCTION

The present study aimed at assessing the net gain of body heat storage induced by a transparent plastic blanket draped over small premature neonates in the prone and the supine positions. Thermal stress is particularly important in premature and small-for-gestational-age infants characterized by high values of the ratio between skin surface area and body mass, the greater this ratio, the greater the body heat exchanges. The large skin permeability enhances body water loss. The risk of hypothermia is particularly increased at birth and during operations on naked neonates implying opening of the canopy (surgical operation, blood sampling and gastric aspiration). In the first day of life, the rate of evaporation can reach 100 $g.h^{-1}.m^{-2}$ in very preterm infants. To prevent the large amount of water loss it is sometimes recommended to cover the neonate with a plastic blanket. In closed incubator Fanaroff et al.[3] pointed out that a transparent plastic heat shield reduces the insensible water loss of 44 % in low birth weight neonates lower than 1250 g and postnatal age less than 10 days. For postnatal age greater than 10 days, the magnitude of this reduction was only 19 %. Bell et al.[2] also reported that the addition of a heat shield in an incubator decreased the water loss by 10 % in infants with mean birth weight of 1570 g. However the efficiency of this solution which depends on the physical environment but also on the inter individual difference in the ability to exchange heat with the environment remains questionable and the use of a plastic blanket is still a controversial topic.

The total heat loss of premature infants depends on various factors such as gestational age, nutritional state, mean skin temperature, body hydromineral balance, vigilance state, metabolic rate and of the postnatal age which modifies the skin keratinisation. Thus, it is difficult to obtain homogeneous data base that takes into account all these factors and there are conflicting data on the effectiveness of plastic blanket. To rule out these confounding factors we use a sweating mannequin the advantage of which is that it measures directly the total heat loss with the environment without interference with these factors.

METHODS

- *Mannequin:*

The multisegment anthropomorphic, sweating mannequin (Belghazi et al.)[1] represents a small-for-gestational-age newborn with a body surface area of 0.086 m^2 and a simulated birth weight of 900g (Fig 1). It was cast in copper and painted matt black (surface emissivity = 0.95). Temperatures at various points of the outher surfaces were measured by attached thermistors (CTN Siemens 10 kΩ at 25 °C, precision ± 0.1 °C after calibration) protected from radiant energy by an aluminium foil patch. To take into account the regional thermal heterogeneity of the surface, each segment was separately heated to reach a set point temperature. The temperature of the surface of the head was set to 36.4 °C, the trunk to 36.6 °C and the upper and lower limbs to 33.3 and 35.5 °C, respectively. These values corresponded to those currently recorded for neonates nursed at thermoneutrality in closed incubators.

• *Simulation ofsweating:*

Contrary to most models found in the literature which only assess dry heat exchanges, the present mannequin can simulate skin water loss. A black cotton stocking water was tightly held onto the surface so as to eliminate any air trapped between the fabric and the mannequin surface.

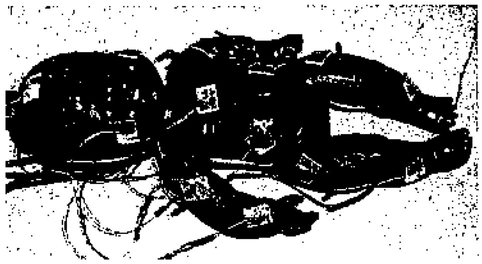

Fig.1: Thermal mannequin lying on the mattress ofthe incubator

A pumping system was used to supply water to the mannequin surface (i.e. simulated skin hydration). It consisted of two peristaltic pumps (MS-CA 4 cassettes, B32089, 40 rpm and Mini-S 3 canaux, B32067, 40 rpm) which were designed for transferring water with a high degree of speed stability and a low pulsation level. Each pump consisted of a rotor with rollers pressing a flexible tube: the water was thus pumped by a peristaltic effect.

The mannequin's segments (head, trunk, two lower limbs, two upper limbs) were separately supplied with water.

Preliminary trials have shown that to perform water evaporation close to the level observed at birth, the mass of water supplied to the nude mannequin could be 4.1 g and 12.5 g (evaporative rates from the mannequin's surface of 117 $g.h^{-1}.m^{-2}$ and 244 $g.h^{-1}.m^{-2}$, respectively). The ratio between these measured evaporative rates and the maximal evaporation recorded for a fully wetted surface (352 $g.h^{-1}.m^{-2}$) corresponds to the surface wettednesses about 30 % and 70 %, respectively. To reach these levels of skin wettedness over each segment, the mass of water supplied was 1.3 g and 4 g for the head, 0.8 g and 2.4 g for the trunk, 0.6 g and 1.8 g for each lower limb and 0.4 g and 1.2 g for each upper limb.

At thermal equilibrium the heat exchanges between the mannequin and the surrounding (expressed in W) can be described by the body heat balance equation:

$$P=\pm K\pm C\pm R-E$$

The heating power (P)supplied to the mannequin balances the total heat losses by conduction (K), convection (C), radiation (R) and evaporation (E).

EXPERIMENTS

The experiments were performed to simulate the first day of life during which skin water loss is very high. The mannequin was lying in a relaxed supine or prone position on a mattress in a single-walled, convectively heated incubator for intensive care or outside the apparatus to simulate surgical operations. The air temperature was 33 °C, air humidity 50 %, air velocity 0.02 $m.s^{-1}$ in the incubator and 25 °C, 50 %, 0 $m.s^{-1}$ outside the apparatus. In each experimental condition the mannequin was nude or covered by a flexible plastic blanket (except the head and an upper limb).

RESULTS AND DISCUSSION

The heat loss from the whole mannequin under the various experimental conditions and the changes in mean body temperature ΔT_b due to the covering are shown in table 1

ΔT_b (in $°C.h^{-1}$) was calculated from the equation of body heat storage $AS = m_b \times C_p \times \Delta T_b$ (where AS is the body heat storage increase induced by the placement of the plastic blanket in W, m_b is the mass of the tissues in kg, C_p is the approximate specific thermal capacities of body tissues in 1 $W.kg^{-1}.°C^{-1}$).

For the covered mannequin, statistical analysis showed that the body position did not significantly modify the heat loss from the whole mannequin inside or outside the incubator whatever the level of the surface wettedness. On the contrary, for the nude mannequin, the total heat loss was significantly reduced *($P < 0.0001$)* by the prone position in all the experimental conditions.

As expected lower heat powers are required to maintain a thermal equilibrium where the mannequin was covered by the plastic blanket. The reduction of heat loss was significant *($P < 0.0001$)* in all experimental conditions. Covering the mannequin prevents a fall of mean body temperature ranging from 3 to 13 $°C.h^{-1}$. The plastic blanket is particularly efficient where the mannequin was placed outside the incubator and for high levels of surface wettedness.

Table.1: Total heat loss from the mannequin in the different experimental conditions.

		Total heat loss (W)			
	Wettedness	Supine position		Prone position	
	surface(%)	Nude	Covered	Nude	Covered
Inside incubator	30%	15.0±0.7	10.1±0.4	12.9±0.9	9.7±0.4
	70%	20.4±0.3	11.2±0.3	17.3±0.4	10.8±0.2
Outside incubator	30%	23.5±0.3	16.8±0.2	20.5±0.5	16.4±0.3
	70%	31.5±0.5	19.5±0.5	28.8±0.4	18.8±0.7

CONCLUSION

The present data points out that this simple device night be useful in very preterm small for gestational age neonates to avoid sudden body hypothermia in the first hours after birth particularly in situations during which large amounts of water can be loss during surgical operations implying the opening of the canopy.

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